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ABSTRACT

Three issues are discussed that relate to (1) the need for the United States to become more technologically competitive and more daring in ways to produce, nurture and encourage high quality research and (2) the state of the talent pool that must produce the scientists, mathematicians and engineers to do this research. The first issue concerns recent declines in the human resources pool in scientific research. Declines in the higher education "pipeline" are reviewed, and suggestions are offered to graduate schools for increasing enrollment among both minority groups and non-minorities. The second issue concerns efforts by the National Science Foundation that have resulted in a commitment by the Federal Government to double its funding over the next 5 years, a commitment that is predicated on the introduction of centers for science and technology designed to improve our national competitiveness. A third issue concerns the anticipated funding, construction, and utilization of a very large particle accelerator called the Superconducting Super Collider (SSC). The commissioning of this facility presents challenges to the physics community and to universities to prepare the graduate students and faculty who will be needed to conduct research in this facility. These challenges involve the preservation of quality in the university and the provision of flexible arrangements to accommodate radical changes in the way frontier research is conducted. (KM)

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SELECTED ISSUES FACING U.S. GRADUATE EDUCATION

by

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INTRODUCTION

I have chosen to address three specific topics during my presentation today. None are new to the audience, and I can only to hope to provide a perspective that may be different from others you have heard.

The issues have to do with the troubling trends in the U.S. scientific human resource picture, the efforts being made at the National Science Foundation to revitalize our research and development activities, and the planning our universities must undertake to accommodate new large-scale facilities such as the SSC in the decade ahead. On the surface, these items may appear to be totally disjoint. I assert, however, that they are connected by a simple theme. Namely, what is the U.S. going to do to make sure that it is more technologically competititve and more daring in identifying ways to produce, nuture and encourage high quality research, and what is the state of the talent pool that must produce the scientists, mathematicians and engineers to do this research.

HUMAN RESOURCES

For a country to excel on a sustained basis in the scientific arena, it must have a continuously repleninshed pool of motivated scientists, engineers, and mathematicians, a sound industrial and governmental funding base, and a society that values the contributions of science to the well-being of its people. One can write several treatises

on each of these topics, but in this section I want to focus on the "replenishment" issue, which happens to be one of particular relevance to the graduate deans assembled here today.

The term economic competitiveness has surfaced prominently in many quarters during the FY1988 budget discussions. In the abstract, it is not clear what one means by the use of this phrase. But in the concrete, one has only to note the impact of the loss of the race to develop a particular micro-chip to see what the implications are, as tens of thousands of individuals lost jobs in California as a result. Just a couple of years ago our country had a trade surplus in high-technology markets of over $4 billion. But in 1986 we had our first absolute trade deficit in the high-technology area, something that would have been unimaginable a few years ago. This should be a source of great concern.

In a report prepared for the National Science Board in 1985 we pointed out that "The most striking and pervasive change in the 1980's - one that is fundamental and irreversible - is the shift to a global economy. The only way we can continue to stay ahead of other countries is to keep new ideas flowing through research; to have the best technically trained, most inventive and adaptable workforce of any nation; and to have a citizenry able to make intelligent judgements about technically-based issues..." It is in this context that there I believe there is reason for concern about the declining enrollments in graduate education at precisely the time when we see that the future will require an increased fraction of our population to have advanced training.

It would be helpful to examine what we know about the higher education section of the so called "educational pipeline":

- overall, the number of undergraduates opting to pursue studies in science is declining. [In the period 1973 - 1983, the number of undergraduate science majors declined by about 15%]

- overall, graduate enrollments are declining [In 1978, the number of Ph.D.s awarded was 32,664; in 1985 the number was 31,253]

- the number of 18-year olds is expected to be significantly below the present value for most of the remainder of this century

- the fraction of the brighest entering freshmen indicating a desire to major in the physical sciences has steadily dropped by a factor of three between 1967 and 1983

- of the 12.3% growth expected in the U.S. population between now and the end of the century, over 60% of this amount will be made up by blacks and Hispanics. By the year 2000, the U.S. population is expected to be one-third minority. If the number of minorities interested in careers in science and engineering is not increased significantly, there will likely be a serious short-fall in meeting national needs in many areas.

- in spite of the serious underrepresentation of minorities in graduate school(receiving less than 5.5% of the doctorates in 1984), there is evidence that the number is in a state of general decline. For example, the black enrollment in graduate schools has declined more than 19% in the past decade.

These observations do not paint a very rosy picture for the future. Active intervention would seem to be justified, and one of the prime participators in such a process should be our universities.

Concerning the question of what the Graduate Schools of the country might do to help in dealing with the minority enrollment issue, I would like to report on some of the action items discussed in a recent conference on the production of minority scholars held at the State University of New York at Stony Brook. This conference was supported by the National Science Foundation and the Carnegie Corporation and, I am pleased to note, had the strong an active participation of several CGS officers.

- to enhance the number of minority students remaining through degree completion, every Graduate School should investigate the implementation of a mentoring program for its minority graduate sctudents, providing appropriate recognition of the special efforts of faculty members who make extraordinary commitments in this area

- every university should examine the possibility of implementing a program, whereby its own outstanding undergraduates are identified early on and encouraged to consider a graduate program at that institution. [This does indeed violate the old maxim that students should go elsewhere for their graduate training; however, there is evidence that many good students stay right where they are and do quite well, and that most of these students are

not minority students -- the very students who might benefit most from not undergoing the traumatic resettlement experience. Moreover, the very act of establishing a supportive contact with a budding scholar helps to reinforce that persons self-confidence, and to inform him or her of what graduate school is all about, even if in the end the student goes to some other fine school.]

There are many other strategies that should be implemented, for the good of all students, minority and non-minority. I respectfully claim that our nation's graduate schools are not doing as good a job as they should in conveying the message to prospective students why they should consider a graduate career. In the absence of good information to the contrary, many students will simply do their own analysis, taking into account only those parameters they can readily identify. For most the predominant considerations are financial costs and the additional term of servitude as a student. These are weighed against the possibility of immediate financial freedom and independence from "studenthood", something that many will have yearned for over sixteen years. If we do not capture their attention during their undergraduate years and tell them that though they have come a long way, but they have a little farther to go to achieve a level of preparation that will uniquely qualify them for a leadership position in their discipline, then we will be doing nothing to counter the natural forces pressing them to exit the educational pipeline at the next bus stop. By no means am I suggesting that graduate school is for everyone. But we are losing just too many talented students, and something should be done to reverse this trend. Graduate deans have a real responsibility here, and I hope that in the years ahead you will take actions to rise to the challenge before you.

NATIONAL SCIENCE FOUNDATION INITATIVES

As many of you are aware, for a period of many years I have been associated with various activities of the National Science Foundation. For the period 1980 - 1986 I served as a member of the National Science Board. I am presently the Chairman of the National Science Foundation's Physics Advisory Panel. My remarks here today, however, are not made in any of these capacities. They originate from the perspective of an individual who greatly values the role the NSF has played in the development of U.S. science, mathematics, and engineering, who endorses the initiatives being taken by the NSF to expand its base of federal support, and who is also pondering the implications of the proposed changes in the modalities of federal research support. My reason for including this as one of the issues in my presentation today is that I regard the full attainment of the doubling of the NSF budget over the next five years as being extraordinarily important, but unlikely to happen unless there is strong and continued community support and pressure at all levels. That support can be insured only if there is a general understanding of the options and issues involved.

The NSF Director and Science Board are to be commended for achieving an agreement with OMB for a program that would lead to the doubling of the NSF budget over the next 5 years. Even then, the NSF budget will be demonstrably smaller than it should be, given the mandate that the agency has for insuring the health of basic research and science education in the U.S. The commitment for a doubled budget was predicated, however, on the introduction of centers for science and technology designed to improve our national competitiveness.

The reaction of several sectors of the academic community to the center concept has been reserved. They would be most willing to take the new money, but are concerned about the implied change in the modalities for conducting research, even if the centers are to never become a major part of the overall NSF program. The fears in this area are heightened by the concern that the NSF may wish to proceed to develop these centers even if the Congressional budget process does not produce the incremental support requested by the President for the NSF. The implication is that the existing base program, e.g., the traditional investigator support program, would bear the brunt of funding these new initiatives. Almost nothing could do more to sharpen the question of " what is the best way to support U.S. research?" Should we have more centralized facilities, with a reduction of the fraction of our support going to individual investigators? Should we direct more of our funds to scientists with extraordinary promise (e.g., Presidential Young Investigators), or do we get more results per dollar by continuing to provide broad base support, with the expectation that startling results might arise almost anywhere in our vast sea of high quality, ongoing research?

These are some of the issues, and in the long run the collective wisdom of the country must be brought to bear on the solution. The Graduate Deans of our U.S. institutions must certainly have something to say on this topic, and should do so. The current thrust on the part of the NSF is one, I would claim, that should be pursued. There are a couple of provisos I would insert (and I have no reason to believe that these are inconsistent with the views of the NSF administration). One is that the current program be viewed as experimental, with data being collected to aid in the development of longer range plans. Second, I urge that the funds for this experiment (and for a selected small number of other initiatives) be taken from the growth funds in the NSF program, and that the "golden goose" -- the single inves-

tigator programs -- be kept at essential parity during these tests. The transistor, laser, NMR imaging, non-linear optics are all examples of even technological strides developed in the settings of traditional university based projects, and we must be careful not to tamper with such a successful strategy. But, as Roland Schmidt, Chair of the National Science Board, pointed out in a recent discussion with me, "how do we know that under a different modality we would have not done better?" That is a fair question, and it is appropriate that a national body such as the NSB precipitate the necessary experiments to extract an answer to this question. To help maintain a reasonable degree of coherence of the university-based scientific community during the testing of innovative options, the help of groups such as CGS could be most useful.

In addition, I especially urge you to support through your congressmen and others the need for a rapid ramping of the NSF budget. Without these new funds, we risk being locked into the current stagnant situation, with almost no opportunity for exploring new avenues. To give you an idea of just where things stand, I want to review some of the gross figures for Physics in the NSF. This example is given only as an example; I am sure that other units within the NSF are suffering similarly.

Comparing the FY1987 NSF Physics budget with the FY1988 budget submitted to Congress, one observes that the Physics Division is scheduled to receive a 12.1% increase (assuming that the full Presidential request is granted -- not a good bet at this stage). Of this 12.1% growth, 2.7% is targeted for science and technology centers, 2.2% for other targeted initiatives such as the PYI program, the Undergraduate Science and Engineering Program, and so on. Another 4.9% is required to fund planned construction projects. This would leave, in the best of circumstances (with the NSF getting the full requested amount in this first year of its doubling scenario)

a sum of 2.3% for the normal university based program, an amount less than inflation. Moreover, this corresponding figure is 0.6% for last year, and -3.6% for the previous year. In sum, the university base program will have regressed some 15-30% over the past three years (depending on the inflationary factor used). Let me hasten to add that the university program has certainly benefitted from certain of the targeted programs over the years, and it would be most inappropriate to totally discount the impact of these programs in making a budget analysis. The point is, however, that the far majority of the nation's scientists will not be see the impact of these special programs, but will see that their grants support significantly less research now than they did three years ago. This example highlights the distribution issue that will need to be resolved in the coming years, and highlights the need for increased NSF funds.

LARGE SCALE FACILITIES

As you are aware, we in high energy physics are looking forward with great expectation to the funding, construction and utilization of a very large particle accelerator called the SSC (Superconducting Super Collider). The device would have a circumfernce of 52 miles, cost approximately 6 billion dollars, and would require roughly a decade for construction. It would permit the exploration of the matter at distances considerably less than 10**(-18) meters. On this distance scale, we could study quarks themselves (quarks, being the constitutents of protons, neutrons, etc.), and study many phenomena important to understanding the ultimate structure of mat-

ter. In January, the National Research Council will announce the next cut in the pending site proposals, and current plans call for the President to announce the final site in January, 1989.

As an individual who played a role in the early design of our present largest accelerator at Fermilab, and who has served on the Board for that and other laboratories, I want to share some thoughts regarding some of the problems both the physics community and universities must prepare themselves to face in the years between now and the commissioning of this new facility. You may be wondering just what this project could possibly have to do with the Council of Graduate Deans; let me try to explain.

It will be your students and faculty who will be scrambling to conduct their frontier research on this spectacularly unique facility. It will be your young faculty who will join your departments in the next few years with the desire to start a 7-year research, development and construction odessey for an experiment at the SSC, even though they will have little to show in the way of original physics publications when it comes time for them to be reviewed for tenure. It will be your graduate students who will want to work on construction and design SSC projects, though there will be no chance for them to complete original thesis work in the traditional sense.

The problem is certainly one that Graduate Deans should be concerned about. You have the responsibility for seeing that the tenets of quality are preserved in your universities, but you also have the responsibility for seeing that flexible arrangements are made to accommodate truly radical changes in the ways that frontier research is conducted.

I have no solution to offer today, and I only seek to alert you to the fact that the problem is going to surface. Moreover, the problem will not be confined just to high energy physics. The new science and technology centers, large scale projects in bio-sequencing, centralized facilities in nuclear physics and condensed matter physics, all point to similiar issues in a broad range of the sciences in the years ahead.

The Department of Energy has formed a sub-panel of HEPAP (High Energy Physics Advisory Panel) to look into this general issue from the perspective of high energy physics. I am a member of the subpanel, and would welcome any direct information you would like to share. Our report is due next spring, and I am sure it will receive widespread distribution, and it will likely call upon your universities to consider interim measures to facilitate the participation of graduate students and young faculty in the SSC project.

CLOSING REMARKS

There are challenging times ahead. Opportunities for failure and spectacular advance abound on almost every front. Universities working in concert with the federal agencies and the private sector can help sustain the course of our country as an innovative and productive nation. The role of graduate deans in guiding their universities through the labyrinth of options and emphases is a critical one, and I urge you to exercise your influence and to enlist the services of your universities in preparing the nation for the 21st century.